On the Structure of the Brain and Auditory Apparatus of a Theromorphous Reptile of the Permian Epoch. By E. D. Cope.

(*Read before the American Philosophical Society, October 16, 1885.*)

The following observations are made on a part of a skull of one of the Diadectidæ (Pelycosauria with transverse molar teeth*), which is accompanied by several vertebræ and other fragments of the skeleton, of a single individual of undetermined species. A few characters are derived from skulls of two allied species, *Diadectes phaseolinus* and *Empedias molaris* Cope, which, like the first named specimen, were derived from the Permian formation of Texas. A cast of the brain chamber was obtained, thanks to the skill of my assistant, Mr. Geismar, first in the elastic material patented by Bendernagel & Co., of Philadelphia, for the manufacture of printers inking rolls; and afterwards in plaster of Paris, in a mould made from the elastic cast.

The brain-case in the Diadectidæ differs from that of the Clepsydropidæ much as that of the Varamidæ differ from those of other Lacertilia. That is, it is continued between the orbits, so as to enclose the olfactory lobes of the brain within osseous walls. These walls are thin; especially at the interorbital region, and in the specimen the anterior extremity is so far imperfect as to leave the form of the anterior fundus in doubt.

The brain in reptiles, as is well known, does not fill tightly the cranial chamber as is the case with the Mammalia, there being a wadding of connective tissue, with interspaces filled with lymph and fat, between it and the cranial walls. In the present species the postfrontal part of the cranium is so contracted that there could have been but little space of this kind, and the superior walls are clearly impressed by the surfaces of the middle brain and the cerebellum. The form of the inferior surface of the brain posterior to the fifth pair of nerves cannot be determined from the specimen examined, owing to the absence of the basioccipital and basisphenoid bones.

The conformation of the cranial walls requires preliminary notice. In the first place the vestibule of the ear can only have been separated from the brain by a membranous septum, as is the case in the *Protonopsis horrida*† (Menopoma). In clearing out the matrix no trace of osseous lamina could be detected on either side, and the edges of the huge foramen thus produced are entire, and present no broken edges. Anterior to the vestibule, the proötic bone has a small extension, terminating in a vertical border. In front of this is the huge vertical foramen through which issues the trigeminus nerve, which is even larger than that found in the Testudinata and Crocodilidæ. The anterior border of this foramen is formed by

*For a definition of this family and the included genera, see Proceedings of the American Philosophical Society, 1880, p. 45.

†See Journal Academy Philadelphia, 1866, p. 105, where the characters of the skull in the Urodela are pointed out.

the probable alisphenoid, whose posterior edge is nearly parallel with the anterior border of the proötic, sloping forwards as it descends. The basicranial axis is thin at their union on the middle line below, and, thickening forwards, is excavated by rather small conical fossa. Anterior to the fossa is a smaller impressed fossa, and on either side of it, each lateral wall is excavated into a shallow fossa which descends towards it. The frontoparietal fontanelle is of extraordinary size.

1. The Brain.

When the superior border of the medulla oblongata at the foramen magnum is placed horizontally, the axis of the brain ascends at an angle of 45° towards the frontoparietal fontanelle. The superior surface, anterior to the foramen magnum, is subquadrate in outline, the angles being truncated, and directed anteriorly, posteriorly and laterally. A posterior constriction connects it with the medulla; and an anterior one defines the middle brain and hemispheres. Each lateral truncated angle represents the foramen of the trigeminus nerve. The space thus bounded is divided into two nearly equal areas by a transverse groove, which extends from the posterior edge of one of these foramina to the other. The posterior of these I suppose to represent the cerebellum, and the anterior the optic thalami. The cerebellar surface indicates that, as in many lizards, the cerebellum is simple, and very slightly convex.

Anterior to the foramen trigemini, the brain contracts so as to have a transverse diameter scarcely more than one-third its vertical diameter. The cast at a point twice as far in advance of the cerebellar line as the fore and aft width of the cerebellum, rises to fill the frontoparietal foramen, forming a mass which represents the huge pineal sac or epiphysis. The proportions of this body are even greater than they are in any of the existing Lacertilia, and it has a greater transverse diameter than the middle brain inferior to it. Its posterior border is at right angles to the line continued forwards from the superior border of the medulla oblongata at the foramen magnum. At its posterior base a flat horizontal process, as wide as the brain at this point, extends posteriorly in a corresponding fossa of the superior cranial wall. Its posterior margin occupies a transverse groove of the superior wall between the superior and inferior plates. Each lateroposterior angle is produced, and may represent the foramen of exit of a narrow canal which appears to perforate the lateral wall and issue beneath the roof of the temporal fossa. A larger projection of each side of the base of the epiphyseal mass occupies a large foramen of the lateral wall, which has the superior wall for its superior border. This may only represent a vacuity of the wall, but the fossa at the posterior base of the epiphysis has greater significance. What this is I am at present unable to ascertain.

Below the epiphysis the transverse diameter of the brain is about one-fourth the vertical, not including a short inferior prominence. The latter is small and conical, and is situated below the center of the epiphysis

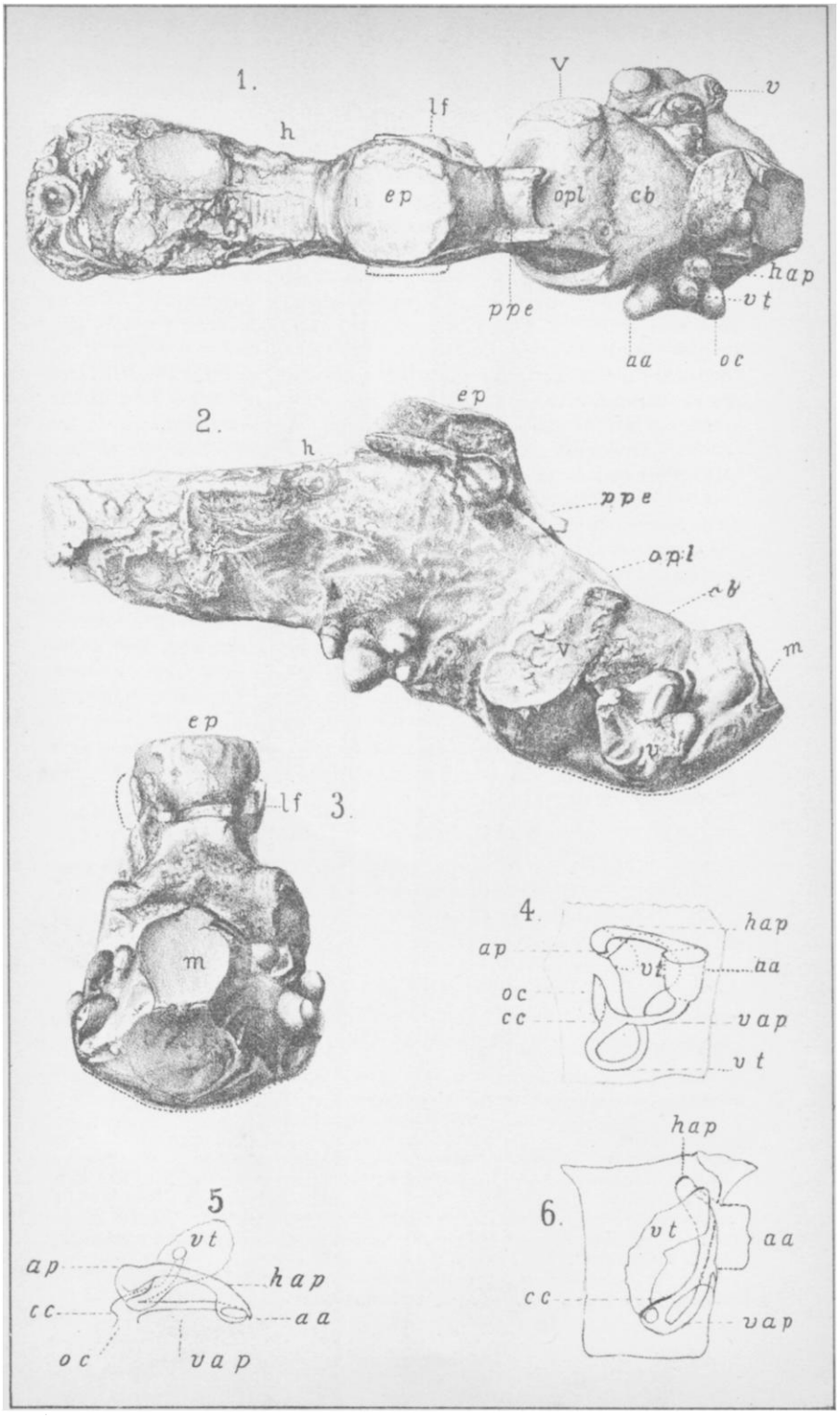
when the cerebellar surface is placed horizontally, or in front of it, when the medulla at the foramen is placed horizontally. Its significance is unknown to me, as it is anterior to the position of the hypophysis. A thickening of the cast on either side of its base converges to the median line posterior to it. I can find no optic foramina, and believe, therefore, that the optic nerves issued from the same large sinus as the trigeminus. The cast diminishes in vertical diameter anterior to the inferior conical process, and increases in transverse diameter of its superior surface. The inferior border continues to be keel-like, so that a vertical section is triangular with the base superior. It is impossible to distinguish the outlines of the cerebral hemispheres or the olfactory lobes, both of which are probably included in this part of the cast, although the latter probably extended much anterior to the extremity of the brain case as preserved. The form may or may not give an idea of the forms of the hemispheres. In any case they were narrower than in any known reptile.

The prominent features of this brain are then the following : The widest part is at the origin of the trigeminus nerve. Both the cerebellum and optic thalamus are flat and simple. The hemispheres are narrower than the segments posterior to them, and of greater vertical diameter. The epiphysis is enormous, and sends a process posteriorly between the tables of the parietal bone. The olfactory lobes were apparently large, and had a greater transverse diameter than the hemispheres. The reduced diameter of the hemispheres is a character of fishes and Batrachia rather than of reptiles, but the thalami are also smaller than is the case in Batrachia. The small, flat cerebellum is rather batrachian than reptilian.

2. The Auditory Apparatus.

As already remarked, the internal wall of the vestibule is not bony, so that the cast of the brain cavity includes that of the vestibule also. On the external wall of the latter are the orifices of the semi-circular canals. These are, one double fossa at the superior anterior part of the wall ; a second double one at the posterior superior part of the wall, and a single orifice at the inferior posterior part of the wall. The external part of the vestibule is produced upwards and outwards to the fenestra ovalis. The "double fossæ" above mentioned are the osseous representatives of the membranous ampullæ at the junction of two pairs of semicircular canals.

On sawing open the periotic bones, which here form a continuous mass, the following is seen to be the direction of the semicircular canals. The superior canal is horizontal. The second canal from the posterior ampulla, descends forwards, and after a course a little longer than that of the horizontal canal, turns posteriorly. The inferior canal from the anterior ampulla also descends, and after a shorter course than the canal last mentioned, also turns backwards and joins it, the two forming a single canal, which enters the vestibule by the single posterior foramen already described. The lumen of the longer perpendicular canal is much larger than



Brain and Internal ear of Diadectidae.

that of the others. As its ampullar orifice is also the largest of all, I suppose this increased diameter to be partly normal; but it may be partly abnormal, as its walls are irregular and rough.

The fenestra ovalis is not preserved in this specimen, but can be seen in the crania of the species *Diadectes phaseolinus* and *Empedias molaris* above mentioned.* The vestibule or a diverticulum from it is produced upwards and backwards, and terminates in a round os. This is clearly not a tympanic chamber, nor is it a rudimental cochlea. It does not appear to be homologous with the recessus labyrinthi, since that cavity is not perforated by the fenestra ovalis. It appears to be a prolongation outwards of the vestibule and sacculus, which may be observed in a less degree in the genus Edaphosaurus (Cope), also from the Texas Permian formation. Here the adjacent bones are produced slightly outwards, and the fenestra ovalis is closed by a large stapes similar in external form to the one I have described in the *Clepsydrops leptocephalus*.† Its more intimate structure I have not yet examined. ‡

The result of this examination into the structure of the auditory organs in the Diadectidæ may be stated as follows: The semicircular canals have the structure common to all Gnathostomatous Chordata. The internal wall of the vestibule remains unossified as in many fishes and a few batrachians. There is no rudiment of the cochlea, but the vestibule is produced outwards and upwards to the fenestra ovalis, in a way unknown in any other family of vertebrates.

I may add that in the specimen examined, the semicircular canals were filled with a white calcareous powder, probably derived from the comminution of otolites.

EXPLANATION OF PLATE.

Figs. 1, 2 and 3 cast of cranial cavity, natural size. As the basicranial axis is lost, the inferior outline posteriorly is provisional only.

Fig. 1, from above.

Fig. 2, from the left side.

Fig. 3, from behind.

The letters signify as follows: *m.*, medulla; *cb.*, cerebellum; *opl.*, optic lobe; *ep.*, epiphysis; *ppe.*, posterior process of epiphysis; *lf.*, lateral foramen; *h.*, region of cerebral hemispheres; *v.*, cast of vestibule; *hap.*,

*See skull of *E. molaris*, Proceedings Amer. Philosoph. Society, 1881, Plate v, figs. *a* and *b*, where the fenestra is represented.

†See Proceedings Amer. Philosoph. Society, 1884, p. 41.

‡Professor Owen has figured (Todd's Encyclopedia, art. Monotremata) a structure in Echidna, which looks remarkably like that here described. This is a tubular elongation of the meatus auditorius externus with more or less cartilaginous walls. This structure might be regarded as homologous with that displayed by the Empedias, could we imagine that with their diminution in size in the Monotreme, the ossicula auditus had retreated within this tube preceding the membranum tympani, from a position at its distal, to one at its proximal extremity. But such a supposition has as yet no foundation, and the very similar parts in the two types may have no homology.

do. of orifice of horizontal anteroposterior semicircular canal; *vt.*, do. of vertical transverse canal; *oc.*, do of os commune of vertical anteroposterior and vertical transverse canals; *aa.*, do. of anterior ampulla; *V.*, cast of foramen of fifth pair of nerves.

Figs. 4, 5 and 6 diagrams of the semicircular canals, natural size.

Fig. 4, interior view.

Fig. 5, anterior view.

Fig. 6, inferior view.

The letters signify as follows: *aa.*, anterior ampulla; *ap.*, posterior ampulla; *hap.*, horizontal anteroposterior canal; *vap.*, vertical anteroposterior canal; *vt.*, vertical transverse canal, enlarged in its upper portion, probably accidentally; *cc.*, canalis communis of the vertical anteroposterior and vertical transverse canals; *oc.*, os commune of do.

Notes on the Mangue; an extinct Dialect formerly spoken in Nicaragua. By Daniel G. Brinton, M.D.

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Sources. Nothing whatever has been published about the Mangue language, except a list of ninety-five words, by Mr. E. G. Squier in his work, "Nicaragua, its People, Scenery and Monuments." Whence he obtained this short vocabulary he does not state; but it is evidently the work of some one only slightly acquainted with the character of the language. I do not make any use of it in the present notes, except in a few instances for comparison.

My authorities are, first, Don Juan Eligio de la Rocha's *Apuntamientos de la Lengua Mangue, MS.* The author was born in Granada, C. A., June 15, 1815. By profession a lawyer, his taste led him to the study of languages, and he acquired a fluent knowledge of French, English and Italian. He was appointed instructor in French and Spanish grammar in 1848 in the University of Leon, C. A., and ten years later, 1858, published his *Elementos de Gramàtica Castellana* (Leon, 1858, small 4to, pp. 199). His death occurred in 1873.

While living in Masaya in 1842, he became interested in the surviving remnants of the Mangues, and undertook to collect materials for a study of their language. Unfortunately, he never completed these investigations, and many of the sheets on which he had recorded his notes were scattered. A few of them, how-